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Electromagnet having a linear drive for the armature

The invention relates to an electromagnet having a soft-magnetic iron circuit, which is separated at its pole ends by an air gap, and having a plunger-type armature which, in its rest position, projects into the operating air gap and, when the electromagnet is energized, assumes a magnetically symmetrical operating position between the abovementioned pole ends.

Electromagnets of the abovementioned type, which are generally referred to as plunger-type armature magnets and operate on the principle of a solenoid magnet, have the significant advantage over conventional electromagnets with a hinged armature, as are used in telecommunications, for example in relays and in switching contactors in large numbers, that, when the electromagnet is energized, the force which is exerted on the armature is approximately constant over a relatively long range of armature movement and decreases toward the end of the movement while, in contrast, in the abovementioned hinged armature magnets, the force is weak in the initial stage and increases even in accordance with a square law toward the end of the armature movement, so that this results in the armature striking the opposite magnetic pole in an undesirably hard manner, which shortens the life of the magnet system, as well as possibly also resulting in contact bouncing. In the case of a plunger-type armature system, on the other hand, the abovementioned force/distance characteristic very largely ensures an ideal response, that is to say a high initial acceleration and free swinging out, or at least the

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armature striking softly. The already known plunger-type magnets have the disadvantage, however, that their iron circuit is not closed, or is closed only incompletely, so that the magnetic efficiency that is achieved is only poor.

Against the background of the abovementioned prior art, the purpose of the present invention is to provide an electromagnet which operates on the plunger-type armature principle and which has all the advantages associated with this plunger-type armature principle and which have already been mentioned in the introduction to the description above, but whose magnetic efficiency is better than the already known designs.

According to the invention, this is achieved in that the pole ends, which form the operating air gap, of the iron circuit are formed from two mutually plane-parallel opposite surfaces, and the armature is in the form of a flat component which can be moved between these surfaces and are composed of ferromagnetic material, and in that, in its rest position, the armature partially magnetically bridges the operating air gap and, when the electromagnet is energized by means of its winding, is drawn into the operating air gap such that it can swing out freely against a restoring force until it assumes its magnetically symmetrical operating position between the pole ends.

This embodiment of the electromagnet ensures that the field flux which runs through the iron circuit finds a closed path in every operating position of the armature so that either a considerably greater magnetic force is produced than with the known plunger-type magnet for the same excitation power, or considerably less

excitation power need be used for the same magnetic force.

If, according to one development of the invention, the armature is coated on its surfaces which face the two pole end surfaces with a coating composed of nonmagnetic material, then this has the advantage that so-called magnetic sticking of the armature against the pole surfaces is avoided, and the armature can thus be moved more quickly and with less friction force.

A further refinement of the invention provided for the pole ends to be in the form of a mechanical guide for the armature during its linear movement. This measure saves additional components and, furthermore, offers the advantage that the guide elements can be connected to the iron circuit such that they cannot move mechanically, so that there is no need for any adjustment, which would necessarily be required for separate guide elements, with respect to the iron circuit or with respect to the armature.

Finally, the scope of the invention includes a spring, which is mechanically connected to the armature, and/or a second electromagnet being provided, in order to reset the armature to its rest position. These alternative options allow the method of operation of the electromagnet to be matched to changing conditions, without any problems.

The invention will be explained in more detail in the following text with reference to the drawing, in which:

Figure 1 shows the force/distance graph for a hinged armature magnet of a known type, as illustrated in Figure 2,

Figure 2 shows a simplified illustration of a hinged-armature magnet of a known type,

Figure 3 shows a force/distance graph for a plunger-type armature magnet designed according to the invention, and

Figure 4 shows a simplified illustration of one exemplary embodiment of the subject matter of the invention.

In the graph in Figure 1, the holding force F which is exerted on the armature is plotted on the ordinate, and the armature movement distance (d-x) is plotted on the abscissa, with d denoting the point of origin of the armature in its rest position. In this case, subject to the precondition that the excitation θ is approximately constant, this results in the curve shown in the graph, from which it can clearly be seen that the force/distance characteristic is extremely poor, since the force F is relatively low in the initial stage of the armature movement, that is to say when the air gap is at its largest, and increases sharply as the operating air gap is increasingly reduced in size, that is to say as the armature increasingly approaches its opposite magnetic pole.

In the arrangement shown in Figure 2, which shows the force/distance response illustrated in the graph in Figure 1 during operation, E denotes an iron circuit, W a field winding, A a hinged armature, F a force which is exerted on the hinged armature when current passes through the field winding to produce a constant excitation θ and (d-x) denotes the armature movement (armature travel) starting from a point of origin d.

To make comparison easier, the graph in Figure 3 once again uses the same reference symbols as those already used in the illustration in Figure 1, that is to say the force +F or -F which is exerted on an armature illustrated in the arrangement shown in Figure 4 is once again plotted on the ordinate and the armature movement (d-x) is plotted on the abscissa, once again in this case starting from the armature in a rest position d and with the excitation θ being approximately constant. The force/distance characteristic, which is shown in idealized form, is extraordinarily advantageous, as can immediately be seen, for the desired aim of the present invention of having high initial acceleration and the armature striking in such a way that it swings out freely, or at least in a heavily damped manner. Specifically, the force +F has a virtually unchanged magnitude, starting from the rest position d of the armature, virtually over the entire distance of the travel, and decreases sharply when the armature reaches the magnetic symmetry position, even with automatic restoration resulting, by means of the force -F, in the case of an armature mounting which can swing out freely and if the armature overshoots its nominal operating position.

The exemplary embodiment of the subject matter of the present invention as is illustrated schematically in Figure 4 has a soft-magnetic iron circuit, which is denoted 1, a field winding 2, two pole ends 3 and 4 and a plunger-type armature 6 which can be moved in the operating air gap 5 between the pole ends 3 and 4 and whose surfaces which come into contact with the pole ends are coated with a layer 7 and 8 of nonmagnetic material in order to avoid any magnetic sticking effect. The force which returns the armature 6 to its rest position is denoted RK and, as has already been

mentioned, can be produced by a spring, which is not shown in any of the cases, or by a further electromagnet.

4 Patent claims
4 Figures

Patent Claims

1. An electromagnet having a soft-magnetic iron circuit, which is separated at its pole ends by an air gap, and having a plunger-type armature which, in its rest position, projects into the operating air gap and, when the electromagnet is energized, assumes a magnetically symmetrical operating position between the abovementioned pole ends, characterized in that the pole ends (3, 4), which form the operating air gap (5), of the iron circuit (1) are in the form of two mutually plane-parallel opposite surfaces, and the armature (6) is in the form of a flat component which can moved between these surfaces and are composed of ferromagnetic material, and in that, in its rest position, the armature (6) partially magnetically bridges the operating air gap (5) and, when the electromagnet is energized by means of its winding (2), is drawn into the operating air gap such that it can swing out freely against a restoring force (RK) until it assumes its magnetic symmetry position between the pole ends.

2. The electromagnet as claimed in claim 1, characterized in that, on its surfaces which face the two pole end surfaces, the armature (6) is coated with a coating (7, 8) composed of nonmagnetic material.

3. The electromagnet as claimed in claim 1 or 2, characterized in that the pole ends (3, 4) are in the form of a mechanical guide for the armature (6) during its linear movement.

4. The electromagnet as claimed in one of claims 1 to 3, characterized in that a spring, which is mechanically connected to the armature, and/or a second

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electromagnet are/is provided for resetting the armature (6) to its rest position.